

AMENDMENTS TO THE CLAIMS

Claims 1-9 (cancelled)

10. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes two program cells that are magnetized in one of two directions, and

when said program unit is in said program state, one of said two program cells in said program unit is magnetized in a direction different from that in a non-program state.

11. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

each of said magnetic storage portions and each of said program cells have a same structure,

when the program unit is in said non-program state, said two program cells in said program unit are magnetized in a same direction, and

a magnetization direction of said magnetic storage portions in an initial state is the same as that of said program cells in said non-program state.

12. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

the two magnetization directions of said magnetic storage portions and said program cells are respectively set along an easy axis specific to said magnetic storage portions and an easy axis specific to said program cells, and

said magnetic storage portions and said program cells are arranged so that said respective easy axes thereof extend in a same direction.

13. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

each of said magnetic storage portions and each of said program cells include

- a first magnetic layer magnetized in a fixed direction,
- a second magnetic layer magnetized either in a same direction as, or in an opposite direction to, that of said first magnetic layer depending on storage data, and
- an insulating film formed between said first and second magnetic layers, and

in each of the program cells in said non-program state and each of the magnetic storage portions in said initial state, said first and second magnetic layers are magnetized in a same direction.

14. (Previously Presented) The thin film magnetic memory device according to claim 13, wherein a step of magnetizing said magnetic storage portions to said initial state and a step of said magnetizing each program cells to said non-program state are conducted simultaneously.

15. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

said memory array further includes

redundant circuits provided respectively corresponding to prescribed blocks of said plurality of memory cells, each for replacing the prescribed block including a defective memory cell, and

said information stored in said program circuit includes a defective address for specifying the prescribed block including said defective memory cell,

said thin film magnetic memory device further comprising:

a redundant control circuit for controlling access to said redundant circuits based on a comparison result between an address signal for selecting said prescribed blocks and said defective address stored in said program circuit.

16. (Previously Presented) The thin film magnetic memory device according to claim 15, wherein

when said defective address is selected by said address signal, said redundant control circuit provides an instruction to access said redundant circuits and an instruction to discontinue access to a prescribed block corresponding to said address signal.

17. (Previously Presented) The thin film magnetic memory device according to claim 15, further comprising:

a monitor terminal for outputting an electric signal according to said comparison result in said redundant control circuit.

18. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

each of said program cells has first and second electric resistances respectively corresponding to said two magnetization directions,

each of said program units further includes current sensing circuits provided respectively corresponding to said program cells,

in program data read operation from said program cells, each of said current sensing circuits applies a bias voltage to the corresponding program cell and outputs a binary voltage signal according to a current flowing through said corresponding program cell by said bias voltage,

each of said program units further includes a logic gate for outputting a first program signal, said first program signal indicating whether said program unit is in said program state or said non-program state according to a level of said binary voltage signal output from said current sensing circuits, and

each of said program units outputs one of said binary voltage signals respectively output from said current sensing circuits as a second program signal indicating a level of said program data.

19. (Previously Presented) The thin film magnetic memory device according to claim 18, wherein

each of said current sensing circuits applies said bias voltage to both a reference resistor having an electric resistance equal to an intermediate value of said first and second electric resistances and the corresponding program cell, and amplifies a difference between currents flowing through said reference resistor and said corresponding program cell and outputs said binary voltage signal.

20. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein a bias voltage applied to each of said program cells in program data read operation from said program cells is lower than a voltage applied to each of said magnetic storage portions in normal data read operation.

21. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein a period during which a bias voltage is applied to each of said program cells in program data read operation from said program cells is shorter than that during which a voltage is applied to each magnetic storage portion in normal data read operation.

22. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

in program data read operation, each program unit outputs a first program signal and a second program signal according to the magnetization directions of corresponding two program cells, said first program signal indicating whether said program unit is in said program state or said non-program state, and said second program signal indicating a level of said program data,

said program circuit further includes data latch circuits provided respectively corresponding to said program units, for holding said first and second program signals output from corresponding one of said program units,

said program data read operation is conducted in response to power-ON of said thin film magnetic memory device, and

said data latch circuits hold said first and second program signals from power-ON until power-OFF of said thin film magnetic memory device.

23. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

when the program unit is in said non-program state, said program cells in said program unit are magnetized in a same direction,

each program cell is magnetized by a first program magnetic field of a hard-axis direction and a second program magnetic field of an easy-axis direction,

said program circuit further includes

a program selection line shared by said two program cells of a same program unit, for receiving a first program current for generating said first program magnetic field, and

first and second program data lines provided respectively corresponding to said two program cells, for receiving a second program current for generating said second program magnetic field, and

said second program current is applied to said first and second program data lines in opposite directions.

24. (Previously Presented) The thin film magnetic memory device according to claim 23, wherein

said program circuit further includes

a voltage setting portion for connecting one end of said first program data line to one of first and second voltages and connecting one end of said second program data line to the other voltage according to a level of said program data, and

a program data line connection portion for electrically coupling the other ends of said first and second program data lines at least in said program data write operation.

25. (Previously Presented) The thin film magnetic memory device according to claim 23, wherein

each of said magnetic storage portions is magnetized by a first data write magnetic field of a hard-axis direction a second data write magnetic field of an easy-axis direction, and

each of said magnetic storage portions and each of said program cells have a same structure and same magnetic characteristics,

said thin film magnetic memory device further comprising:

a plurality of write selection lines provided respectively corresponding to memory cell rows, for receiving a first data write current for generating said first data write magnetic field in a selected row;

a plurality of write data lines provided respectively corresponding to memory cell columns, for receiving a second data write current for generating said second data write magnetic field in a selected column; and

a current supply circuit for supplying a prescribed current to a write selection line of said selected row as said first data write current, wherein

said current supply circuit supplies said prescribed current to said program selection line as said first program current in said program data write operation.

26. (Previously Presented) The thin film magnetic memory device according to claim 23, wherein

each of said magnetic storage portions is magnetized by a first data write magnetic field of a hard-axis direction a second data write magnetic field of an easy-axis direction, and

said magnetic storage portions and said program cells have a same structure and same magnetic characteristics,

said thin film magnetic memory device further comprising:

a plurality of write selection lines provided respectively corresponding to memory cell rows, for receiving a first data write current for generating said first data write magnetic field in a selected row;

a plurality of write data lines provided respectively corresponding to memory cell columns, for receiving a second data write current for generating said second data write magnetic field in a selected column; and

a current supply circuit for supplying a prescribed current to a write data line of said selected column as said second data write current, said prescribed current having a direction according to write data, wherein

said current supply circuit supplies said prescribed current to said program data lines as said second program current in said program data write operation.

27. (Previously Presented) The thin film magnetic memory device according to claim 10, wherein

each of said program cells includes a plurality of series-connected magneto-resistance elements, and

each of said magneto-resistance elements have a same structure and same magnetic characteristics as those of each of said magnetic storage portions.

28. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells for magnetically storing data, wherein each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in operation of said thin film magnetic memory device, wherein

said program circuit includes

a program element for magnetically storing program data of said information,

a sensing circuit for reading said program data from said program element in response to power-ON of said thin film magnetic memory device, and

a data latch circuit for holding said program data read by said sensing circuit until power-OFF of said thin film magnetic memory device.

29. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells each magnetically storing one-bit data, wherein

each of said memory cells has a magneto-resistance element whose electric resistance varies when said magneto-resistance element is magnetized in a direction according to said data,

said thin film magnetic memory device further comprising:

a plurality of program registers each storing a one-bit program signal for use in programming of information used in operation of said thin film magnetic memory device, wherein

each program register includes

a plurality of program elements each having an electric resistance varying according to a magnetization direction thereof, and

a sensing circuit for reading a corresponding one-bit program signal according to a difference in electric resistance between said plurality of program elements, and

the number of said program elements included in each of said program registers is greater than that of said magneto-resistance elements used in each of said memory cells to store one-bit data.

30. (Previously Presented) The thin film magnetic memory device according to claim 29, wherein

each of said program elements and each of said magneto-resistance elements include

- a first magnetic layer magnetized in a fixed direction,
- a second magnetic layer magnetized either in a same direction as, or an opposite direction to, that of said first magnetic layer depending on said data and said program signal to be stored, respectively, and

an insulating film formed between said first and second magnetic layers, wherein a difference between voltages applied to said first and second magnetic layers of each of said program elements upon reading said program signal is greater than that between voltages applied to said first and second magnetic layers of each of said magneto-resistance elements upon reading said data.

31. (Previously Presented) The thin film magnetic memory device according to claim 29, wherein

each pair of program registers forms a program unit for storing one-bit program data, and said one-bit program signal stored in one program register of said pair of program registers indicates whether said program unit is in a non-program state or a program state.

32. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells for magnetically storing data, wherein

each of said memory cells includes a magneto-resistance element having either a first electric resistance or a second electric resistance higher than said first electric resistance when being magnetized in a direction according to said data,

said thin film magnetic memory device further comprising:

a plurality of program registers each storing a one-bit program signal for use in programming of information used in operation of said thin film magnetic memory device, wherein

each of said program registers includes a plurality of program elements each having an electric resistance varying according to a magnetization direction thereof,

each of said program elements has either a third electric resistance lower than said first electric resistance or a fourth electric resistance higher than said third electric resistance according to said one-bit program signal stored therein, and

a ratio between said first and second electric resistances is equal to that between said third and fourth electric resistances.

33. (Previously Presented) The thin film magnetic memory device according to claim 32, wherein

each of said program elements and each of said magneto-resistance elements includes
a first magnetic layer magnetized in a fixed direction,
a second magnetic layer magnetized either in a same direction as, or an opposite direction to, that of said first magnetic layer depending on said data and said program signal to be stored, and

an insulating film formed between said first and second magnetic layers, wherein

a current passage area in said first and second magnetic layers and said insulating layer upon reading said program signal from each of said program elements is greater than that in said first and second magnetic layers and said insulating layer upon reading said data from each of said magneto-resistance elements.

34. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and

a magnetization direction of each said magnetic storage portion in an initial state is the same as that of each said program cell in a non-program state.

35. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

Application No.: 10/691,513

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and wherein

the magnetization directions of each said magnetic storage portion and each said program cell are respectively set along an easy axis specific to said program cell, and

said magnetic storage portion and said program cell are arranged so that said respective easy axis thereof extend in a same direction.

36. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and wherein

each said magnetic storage portion and each said program cell include

- a first magnetic layer magnetized in a fixed direction,
- a second magnetic layer magnetized either in a same direction as, or in an opposite direction to, that of said first magnetic layer depending on storage data, and
- an insulating film formed between said first and second magnetic layers, and

in each said program cell in said non program state and each said magnetic storage portion in said initial state, said first and second magnetic layers are magnetized in a same direction.

37. (Previously Presented) The thin film magnetic memory device according to claim 36, wherein a step of magnetizing said magnetic storage portions to said initial state and a step of said magnetizing each program cells to said non-program state are conducted simultaneously.

38. (Previously Presented) A thin film magnetic memory device, comprising: a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and wherein

said memory array further includes
redundant circuits provided respectively corresponding to prescribed blocks of said plurality of memory cells, each for replacing the prescribed block including a defective memory cell, and

said information stored in said program circuit includes a defective address for specifying the prescribed block including said defective memory cell,

said thin film magnetic memory device further comprising:
a redundant control circuit for controlling access to said redundant circuits based on a comparison result between an address signal for selecting said prescribed blocks and said defective address stored in said program circuit.

39. (Previously Presented) The thin film magnetic memory device according to claim 38, wherein

when said defective address is selected by said address signal, said redundant control circuit provides an instruction to access said redundant circuits and an instruction to discontinue access to a prescribed block corresponding to said address signal.

40. (Previously Presented) The thin film magnetic memory device according to claim 38, further comprising:

a monitor terminal for outputting an electric signal according to said comparison result in said redundant control circuit.

41. (Previously Presented) A thin film magnetic memory device, comprising: a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and wherein

a bias voltage applied to each said program cell in program data read operation from said program cell is lower than a voltage applied to each said magnetic storage portion in normal data read operation.

42. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of

data read operation and data write operation from and to said plurality of

memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and wherein

a period during which a bias voltage is applied to each said program cell in program data read operation from said program cell is shorter than that during which a voltage is applied to each said magnetic storage portion in normal data read operation.

43. (Previously Presented) A thin film magnetic memory device, comprising:

a memory array having a plurality of memory cells arranged in a matrix, for magnetically storing data, wherein

each of said memory cells has a magnetic storage portion for storing data when being magnetized in one of two directions,

said thin film magnetic memory device further comprising:

a program circuit for storing information for use in at least one of data read operation and data write operation from and to said plurality of memory cells, wherein

said program circuit includes a plurality of program units for storing program data of said information when the program unit is in a program state,

each of said program units includes at least one program cell that is magnetized for data writing, and wherein

a voltage supplied to each said program cell in program data operation by a physical breakdown operation is higher than a voltage applied to each said magnetic storage portion in normal data read operation.

44. (New) A semiconductor memory device, comprising:

a first memory including normal memory cells for storing data therein;

an address decoder coupled to said first memory and selecting the normal memory cells according to the address provided to the semiconductor memory device; and

a redundant controller coupled to said address decoder and including a second memory for storing addresses of the defective normal memory cells of said first memory, wherein said second memory has a magneto-resistance element;

said semiconductor memory device further comprises

a third memory including spare memory cells for repairing the defective normal memory cells; and

a redundant address decoder coupled to said redundant controller and said third memory, and selecting the spare memory cells according to the address stored in said second memory.